

3.28 RANGE TRACK

The function of the range tracker in ESAMS is to continuously update the radar range gate to the measured target slant range. Range tracking is typically implemented by using some form of error sensing, such as a split range gate, to determine the error between the perceived target range and the position of the range gate. The range servo attempts to correct the position of the range gate by minimizing the error.

The split gate range discriminator used in ESAMS is illustrated in Figure 3.28-1. The difference in energy between the early gate and late gate is used to generate the error signal. The error signal drives the servo, and the range gate center is then repositioned to align with the perceived target range.

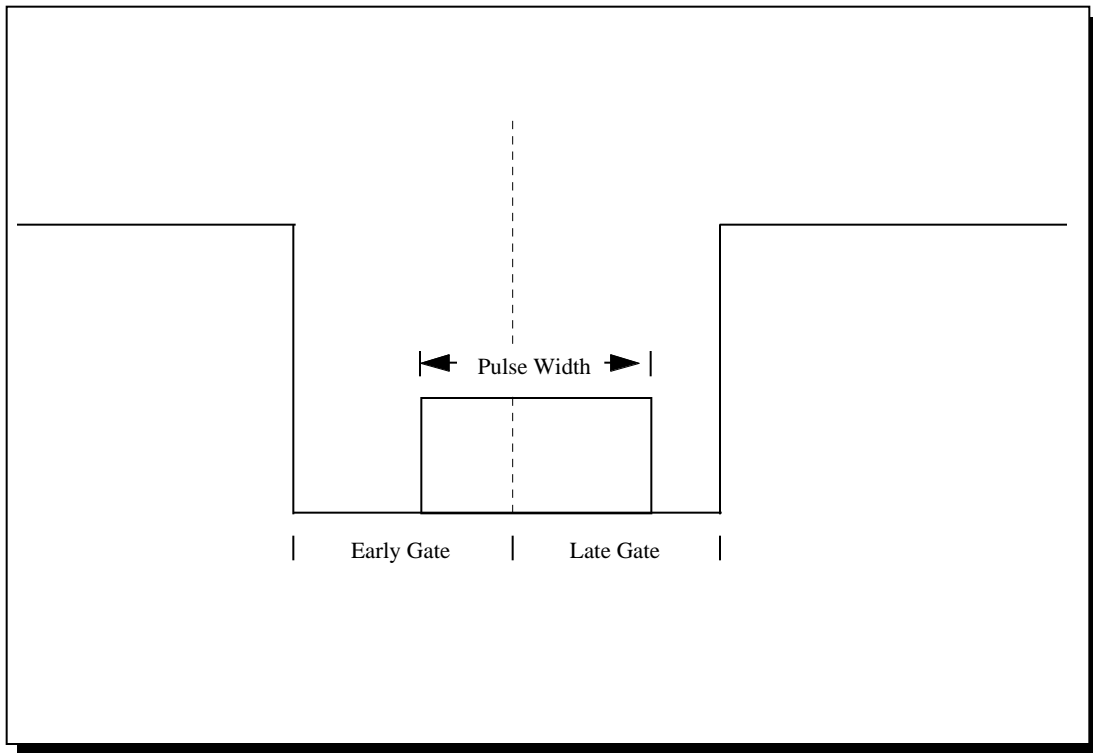


FIGURE 3.28-1. Split Range Gate Discriminator.

ESAMS assumes a square pulse and if the difference between the gate center and the returned pulse center is R_d , then the time difference of this error will be:

$$t_d = \frac{2R_d}{c}$$

where c is the speed of light, and the factor 2 results from the round trip delay of the pulse. For a stronger signal in the late gate, the integrated signals in the early and late gates will be:

$$S_{early} = V \frac{t_p}{2} - t_d$$

and

$$S_{late} = V \frac{t_p}{2} + t_d$$

where t_p and V are the pulse width and pulse amplitude, respectively. The range error can then be obtained from the equation:

$$R_d = \frac{ct_p}{4} \frac{S_{late} - S_{early}}{S_{late} + S_{early}}$$

As for the angle track servos, ESAMS uses several different range servo representations including the improved type I, and type II servos whose general form is given in section 3.27, the GHK servo, and several threat-specific servos.

3.28.1 Objectives and Procedures

The objective of this analysis was to vary the servo gain in one range servo and examine the effect on the step response and overall radar tracking and missile flyout performance. The range track servo type is specified by the RDRD variableIRSTYP, and for this analysis, we selected the servo type withIRSTYP=9.

As for the angle track analyses, the step response was obtained by identifying the appropriate subroutines that model the servos and their initialization and developing a driver to input the step input. The comparison of target tracking errors and missile flyout performance was done by changing the filter gain in RNGSV1 and comparing azimuth and elevation tracking errors written to logical unit 50 and the missile flyout trajectories in the standard output file.

3.28.2 Results

The servo gain in subroutine RNGSV1 is specified by the variable, GAIN, and has the default value of 16. For this sensitivity analysis, gain values of 8, 16, 24, and 32 were chosen, and their corresponding step response and effect on target tracking errors and missile flyout performance were examined. The step response curves are plotted in Figure 3.28-2, and they illustrate that the higher the filter gain, the shorter the rise and settling times of the filter.

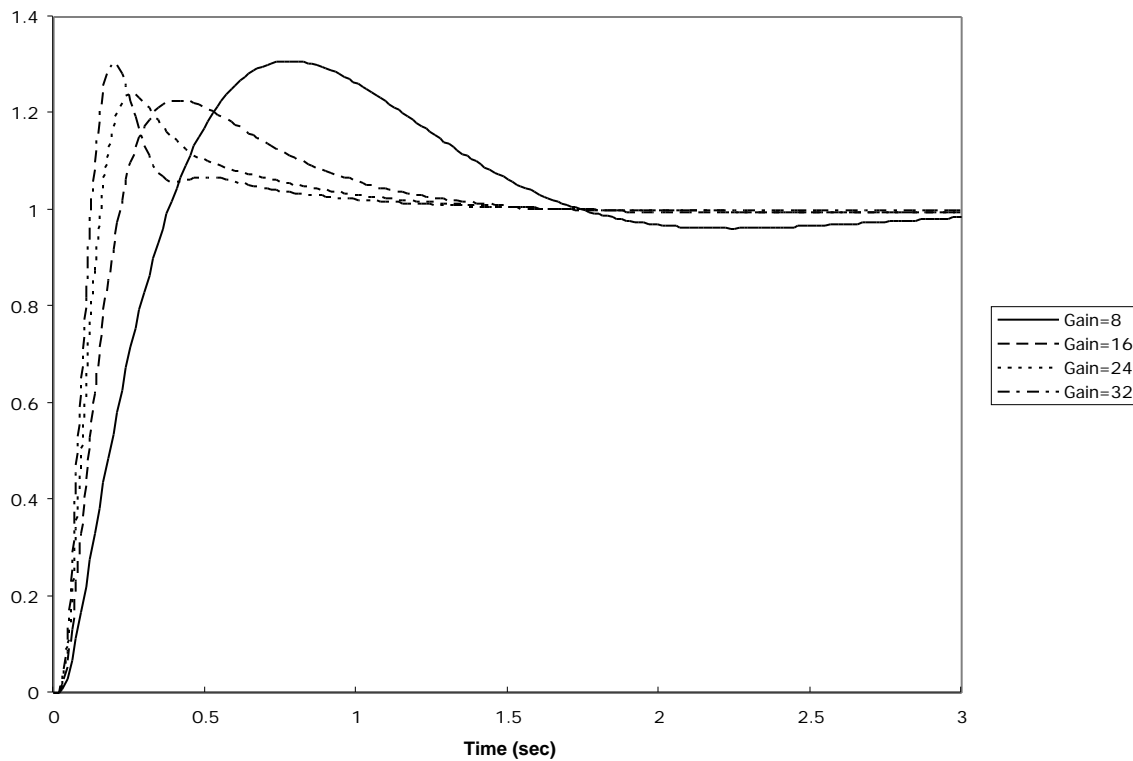


FIGURE 3.28-2. Step Responses for Range Track Servo as a Function of Servo Gain.

The range tracking errors corresponding to the different filter gains are plotted in Figure 3.28-3. Filter gains of both 8 and 16 result in range tracking errors with a standard deviation on the order of centimeters; however, when the gain is increased to 24 and 32 something peculiar happens. The tracking errors start to vary sinusoidally with varying frequency and amplitude.

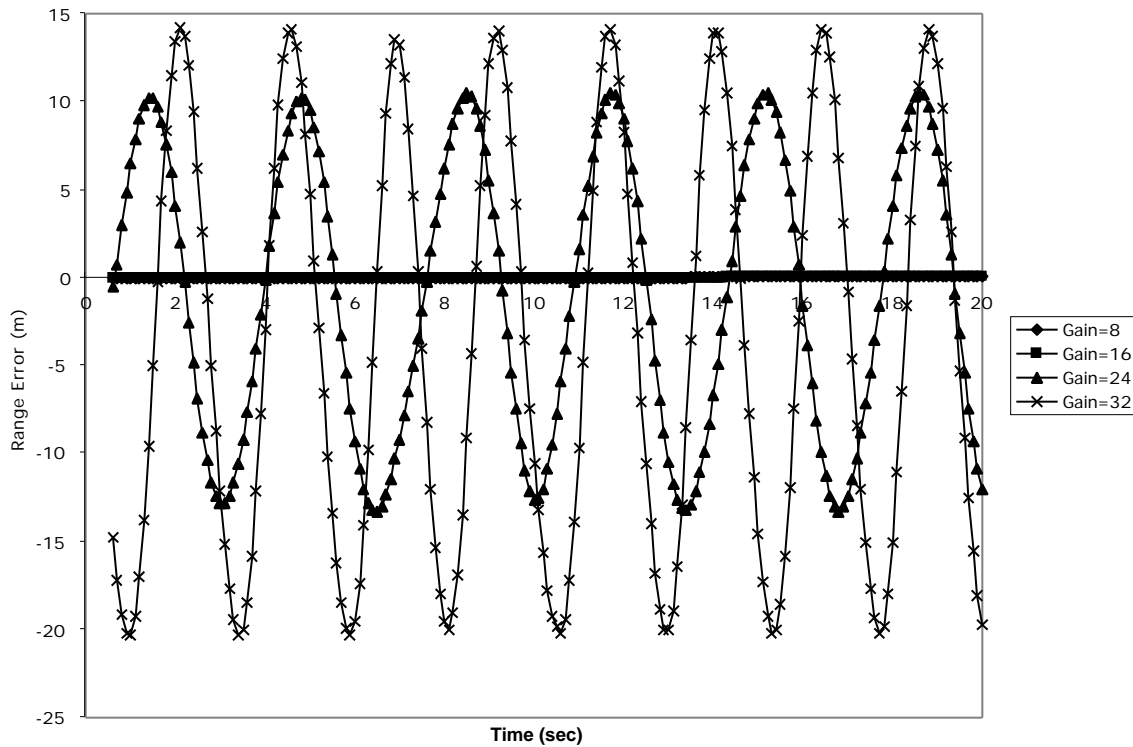


FIGURE 3.28-3. Range Tracking Errors as a Function of Servo Gain.

Investigation of this anomaly revealed that the update rate for the filter set at initialization and the rate at which the filter was being called did not match. The filter is initialized to the missile update rate (specified by the variable, GDT), and it is called at the waveform group update interval (GRPDUR). When the filter update rate is initialized with the group processing interval, the range tracking errors plotted in Figure 3.28-4 are obtained.

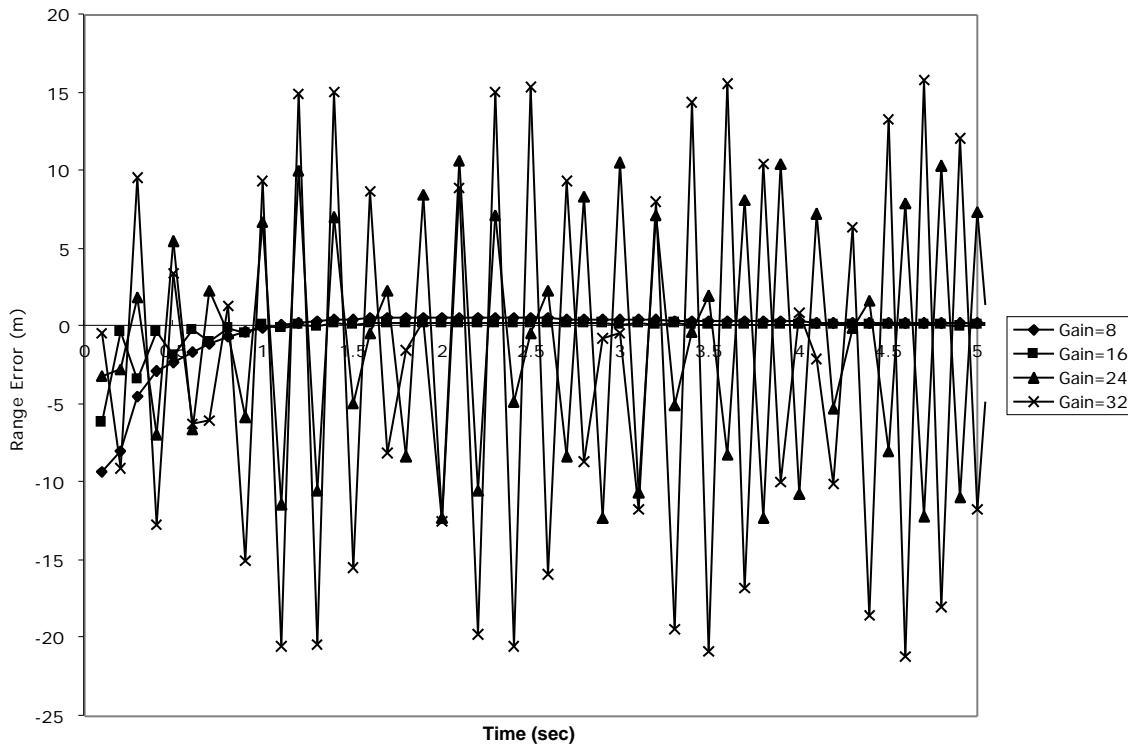


FIGURE 3.28-4. Range Tracking Errors as a Function of Servo Gain with Corrected Update Rate.

Correction of the filter update rate did not eliminate the periodic oscillations in tracking errors. The frequency is now higher, but the amplitude is approximately the same. In order to further investigate this apparent anomaly, the range tracking servo characteristics were examined in greater detail.

Unlike the Improved Type I and Type II servos which track a ramp input with zero error, the threat specific filter used with IRSTYP=9 does not have this property. An off-line driver to generate the response to a ramp input was developed and the response curve is plotted in Figure 3.28-4. With the ramp input response illustrated in Figure 3.28-5, it is plausible that the periodic tracking errors observed in Figure 3.28-4 could result with sufficiently high filter gains.

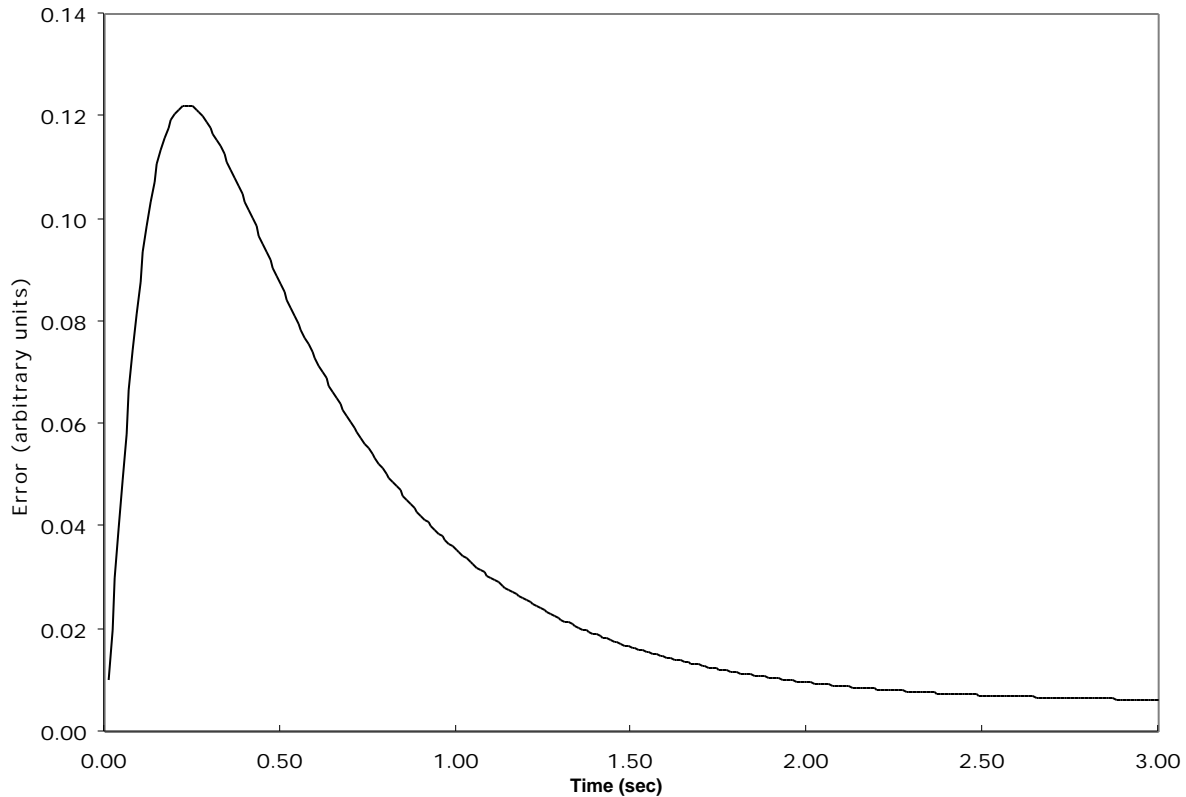


FIGURE 3.28-5. Range Filter Error to a Ramp Input.

For model users only interested in missile flyout and endgame information, none of the tracking errors plotted in Figure 3.28-3 have any significant effect. The missile trajectories and miss distance for all four range track filter gains were identical for the intercept geometry examined.

3.28.3 Conclusions

Range tracking errors obtained with ESAMS are on the order of centimeters and are unrealistically small. This is a result of many implicit assumptions such as, e.g. perfectly stable PRF, perfect square-wave pulse shape, and a point source target. The assumptions of perfect PRF and pulse shape are examined in Section 3.15 under the waveform functional element.

By changing the filter gain, significantly different step responses can be obtained. Higher gain results in larger range tracking errors; however, missile flyout trajectories and miss distances were unaffected for the engagement conditions examined.